Kwan-Liu Ma

University of California at Davis

Mission

The mission of the UltraVis Institute is to enable extreme-scale knowledge discovery by advancing the state of visualization technologies, fostering awareness of and communication about new visualization technologies, and by putting these technologies into the hands of application scientists, especially SciDAC application teams. These goals are being achieved by:

- Performing basic research in algorithms, interfaces, and architectures for visualization, publishing the results of the work, and incorporating successful technologies into a handful of state-of-the-art tools for knowledge discovery across multiple application domains
- Working one-on-one with SciDAC application scientists to accelerate the adoption of Institute tools by these teams
- Organizing workshops, panels, and tutorials that foster interaction within the community and between visualization experts and application scientists
- Educating the next generation of visualization researchers

Ultravis Institute Investigators

- Director: Kwan-Liu Ma, UC Davis (parallel visualization)
- Associate Director: Robert Ross, ANL (parallel I/O)

- Jian Huang, University of Tennessee (distributed visualization)
- Greg Humphreys, University of Virginia (parallel systems)
- Nelson Max, UCD (rendering algorithms and flow visualization)
- Kenneth Moreland, Sandia National Laboratory (visualization tools)
- John Owens, UCD (graphics hardware)
- Han-Wei Shen, The Ohio State University (visualization algorithms)

- + Deborah Silver, Rutgers University (feature extraction & tracking)

Research

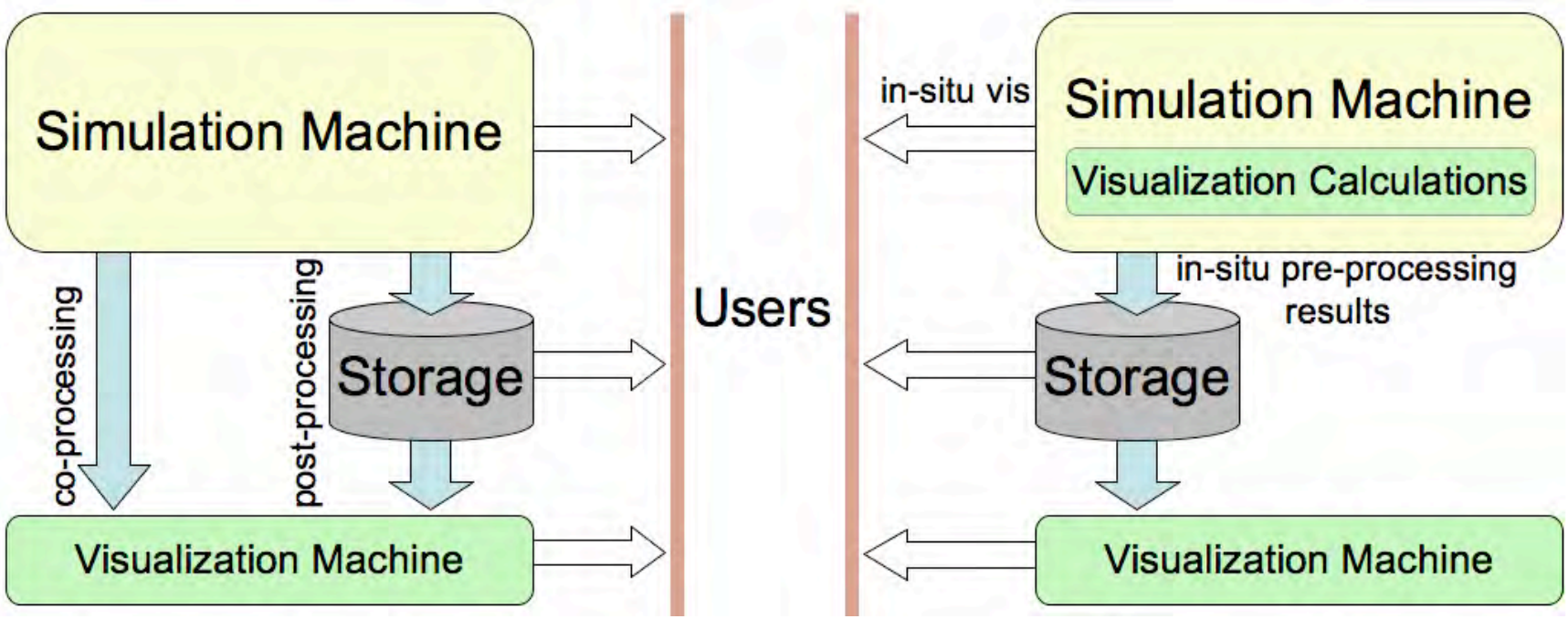
- Science application driven

- Seeing the previously unseen
- More effectively communicate with others their findings

- Parallel visualization
- In situ processing for visualization
- Novel **interface** and interaction designs
- Visual **analytics**
- **Trustworthy** visualization
- **Scalable** visualization
- **Integrated** solutions

In Situ Visualization

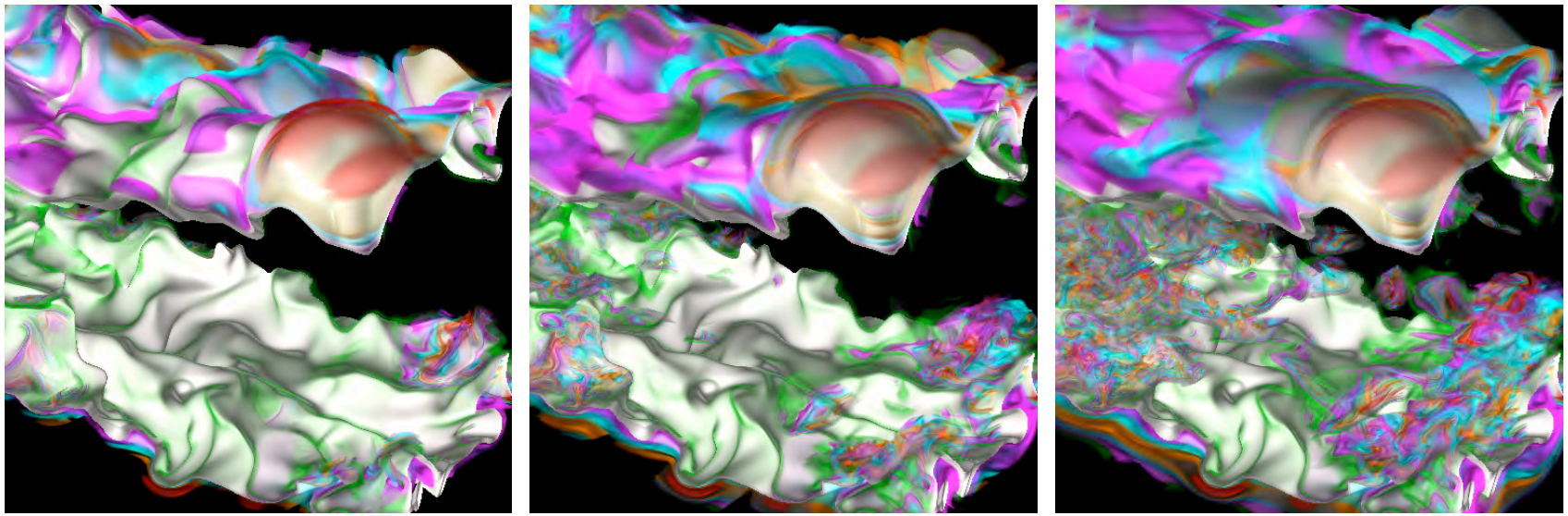
Lead: Kwan-Liu Ma



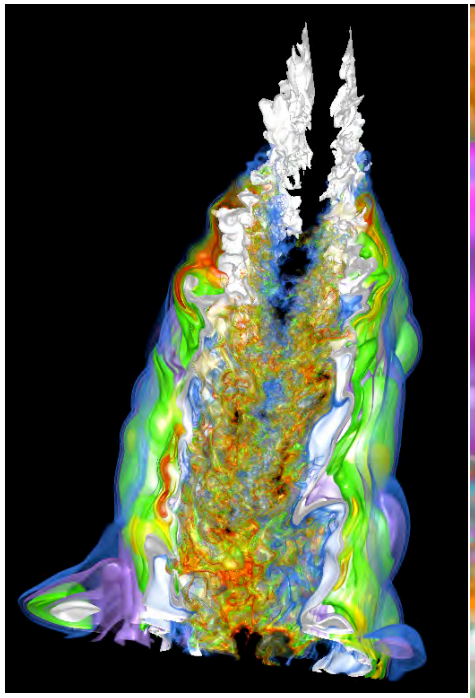
- Collaborator: Jackie Chen, Sandia
  Paul Fischer and Mike Papka, Argonne
- Visual monitoring, data reduction, indexing, rendering, feature extraction, etc.
- Publication: Journal of Physics (SciDAC 2007)
  IEEE Transactions on Visualization and Computer Graphics, May/June 2008

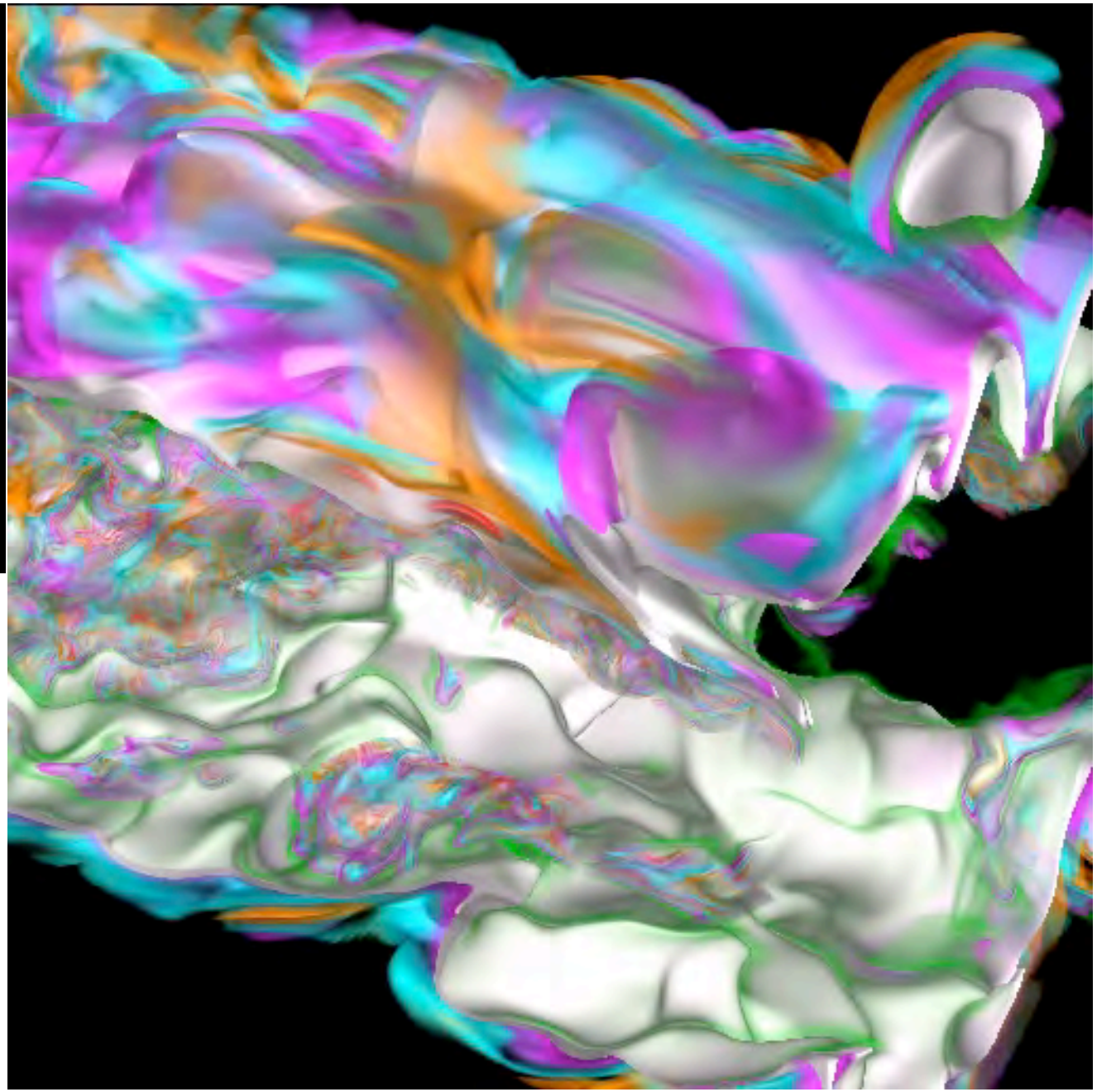
Application Driven Visualization

Lead: Kwan-Liu Ma



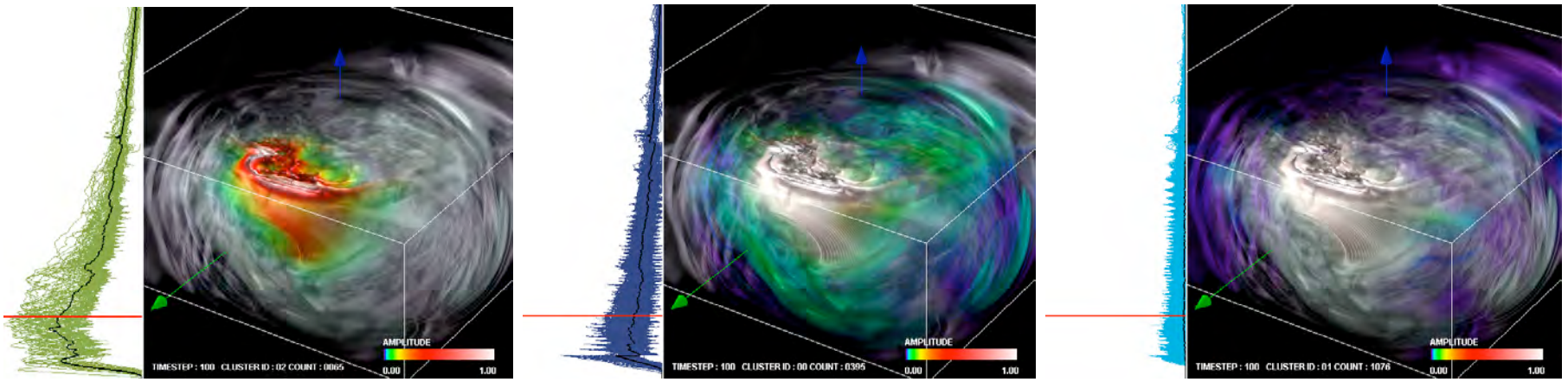
- Collaborator: Jackie Chen, Sandia
- Application driven data reduction, interactive visualization and exploration
- Publication: IEEE Computer Graphics and Applications, 2009





Time-Varying Data Analysis and Visualization

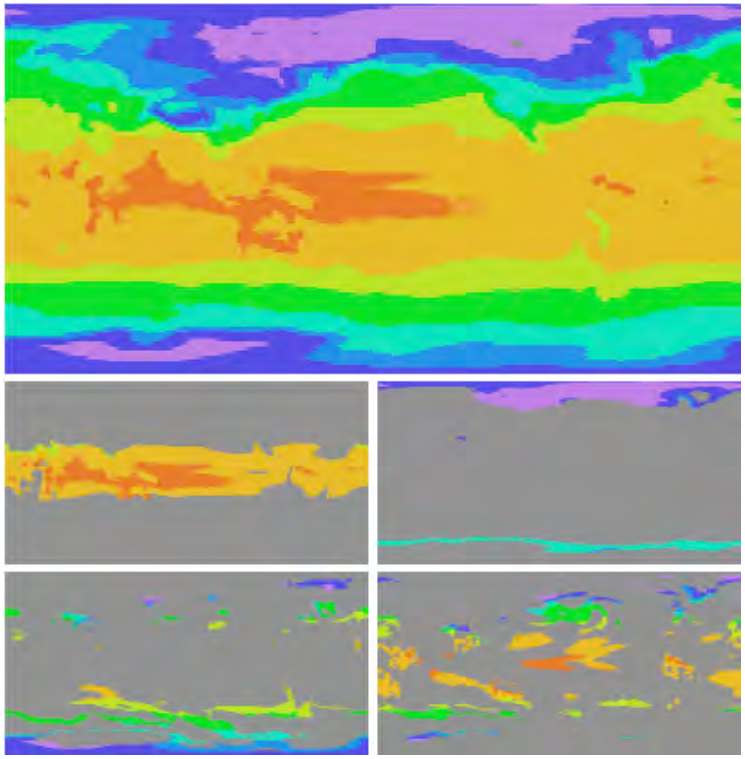
Lead: Kwan-Liu Ma



- Collaborator: Jackie Chen (Sandia), Andrew Wittenberg (NOAA), Tony Mezzacappa (ORNL), …
- Data analysis and partitioning, reduction, feature extraction and tracking, interactive visualization and exploration
- Publications: Visualization 2008 Conference, IEEE TVCG, …

Multi-scale Time-Varying Data Exploration

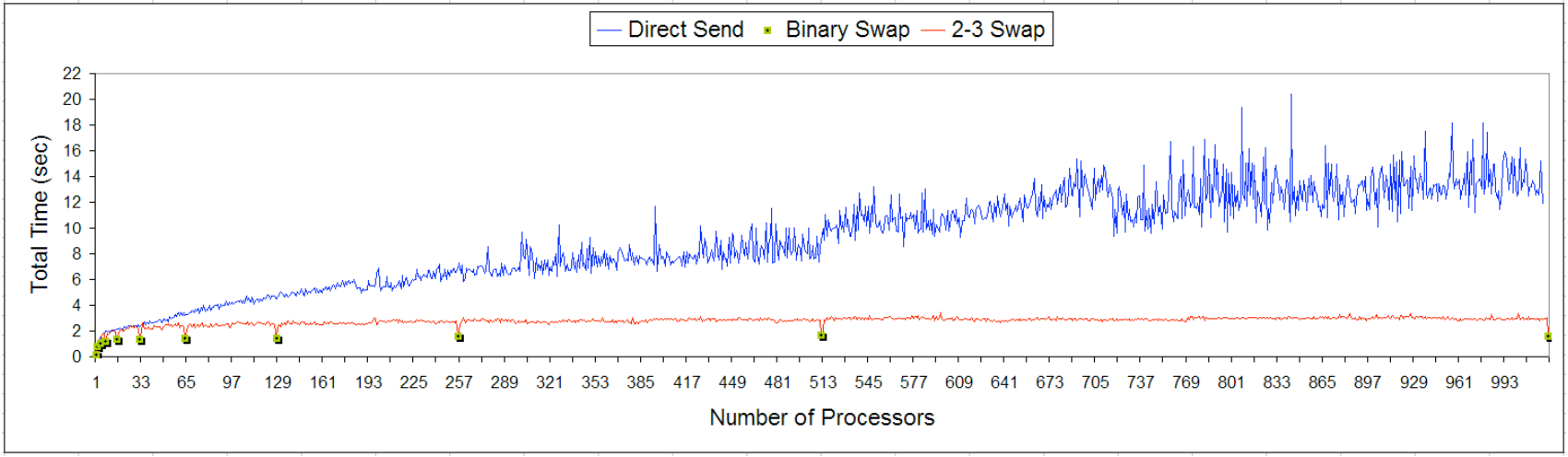
Lead: Han-Wei Shen



- To study both the short term and long term trends from large scale time-varying scientific data (e.g. climate modeling simulation data)
- Multiscale wavelet analysis of time activity curve from each spatial data point
- Classify the data into different spatial/temporal correlated regions
- Spreadsheet-like user interface to support user queries for data of different temporal behavior
- Publication: IEEE Transactions on Visualization and Computer Graphics, 2009

Parallel Image Compositing

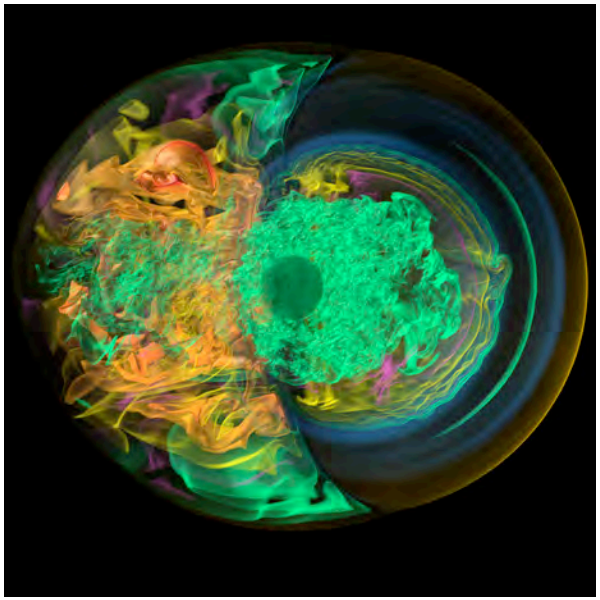
Lead: Kwan-Liu Ma

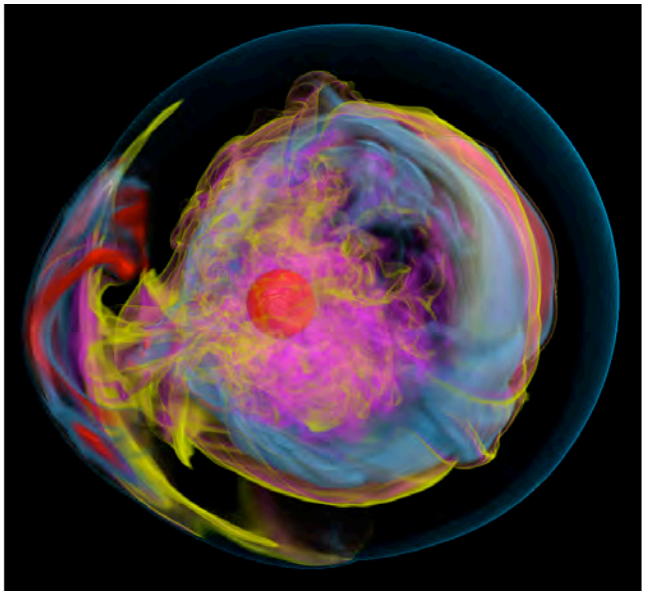


- Collaborators: Kenji Ono (Riken Labs, Japan), Argonne, …
- Key step to scalable rendering at very large scale
- Publication: SC08

Massively Parallel Visualization on Leadership Computing Facilities

Lead: Rob Ross





- The Ultravis team has demonstrated scalable performance on the Argonne Leadership Computing Facility Blue Gene/P system using up to 32,000 processing units, largest ever used in a study.
- This new level of scalable visualization is achieved by the introduction of a new parallel rendering algorithm and the effective employment of parallel I/O support
- Scalable visualization is key to capturing hidden, complex structures in peta/exa-scale
- Publications: SC08 and 2008 Parallel Graphics and Visualization Symposium

GPU Libraries

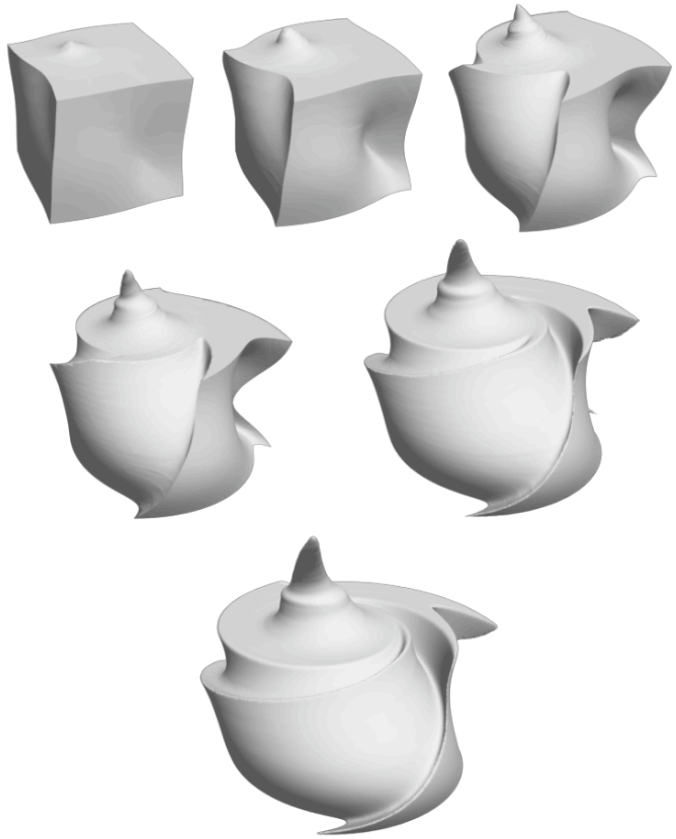
Lead: John Owens

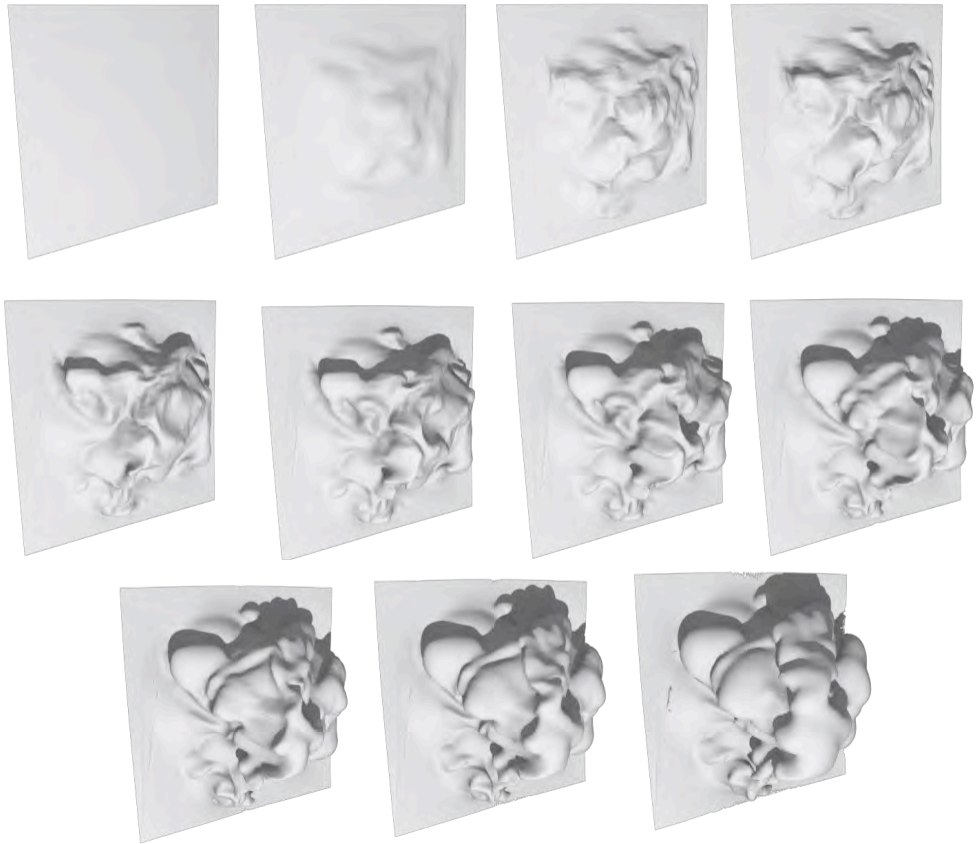
- Hardware acceleration to support both general purpose and graphics computing
- CUDA Data Parallel Primitives (CUDPP)
- Multi-GPU support

- Collaborators: NVIDIA and several other industrial partners
- Publications: Graphics Hardware 2007, ACM Transactions on Graphics

Flow Visualization by Surface Advection

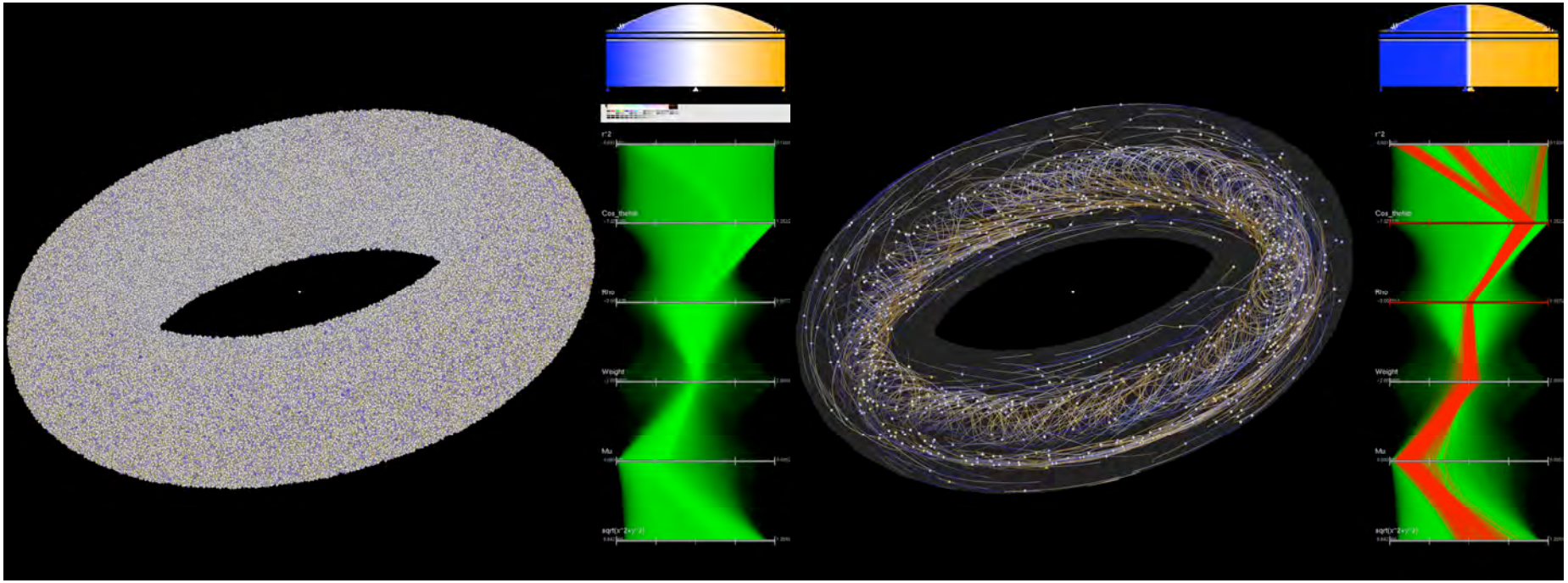
Lead: Nelson Max



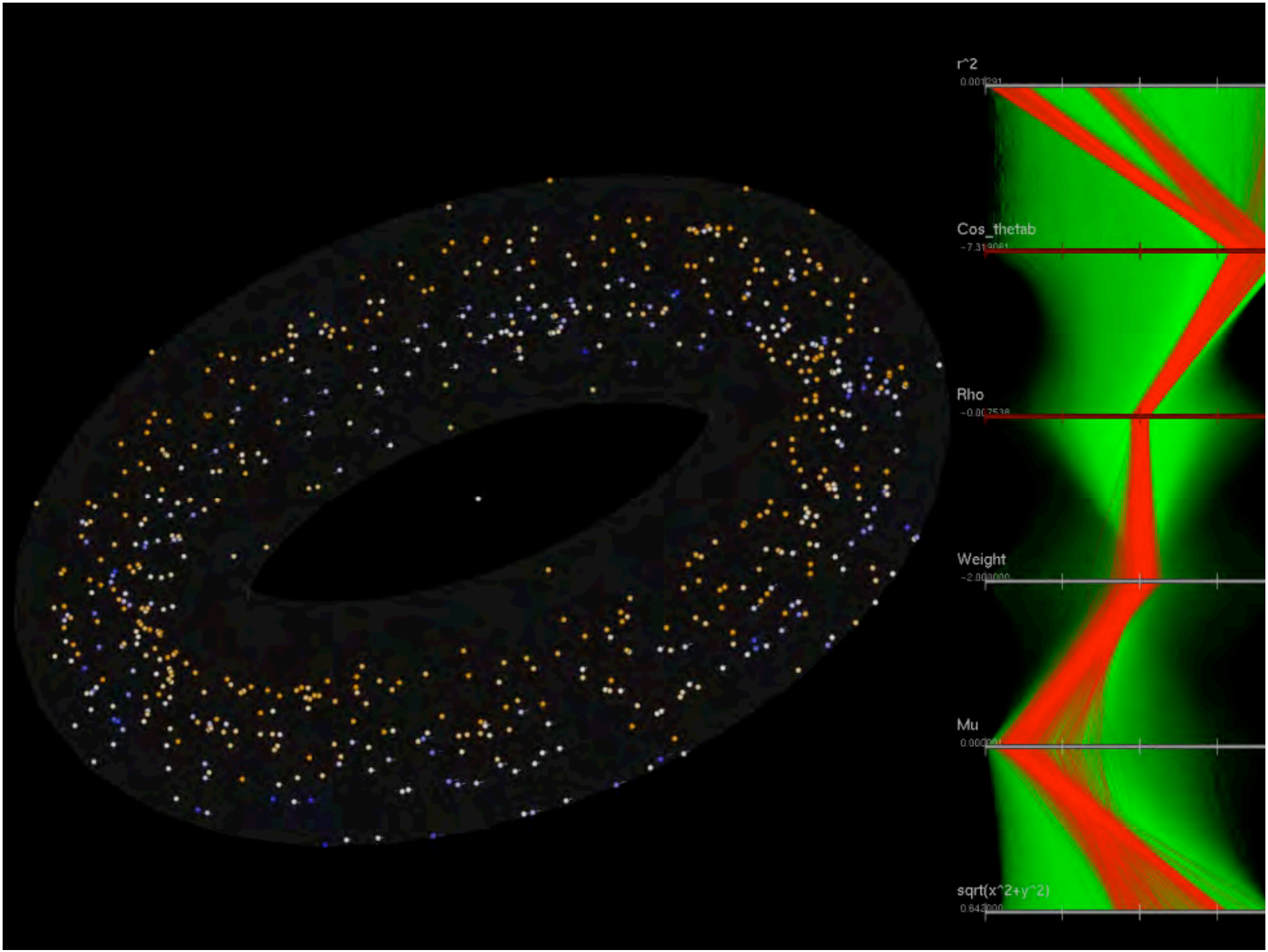


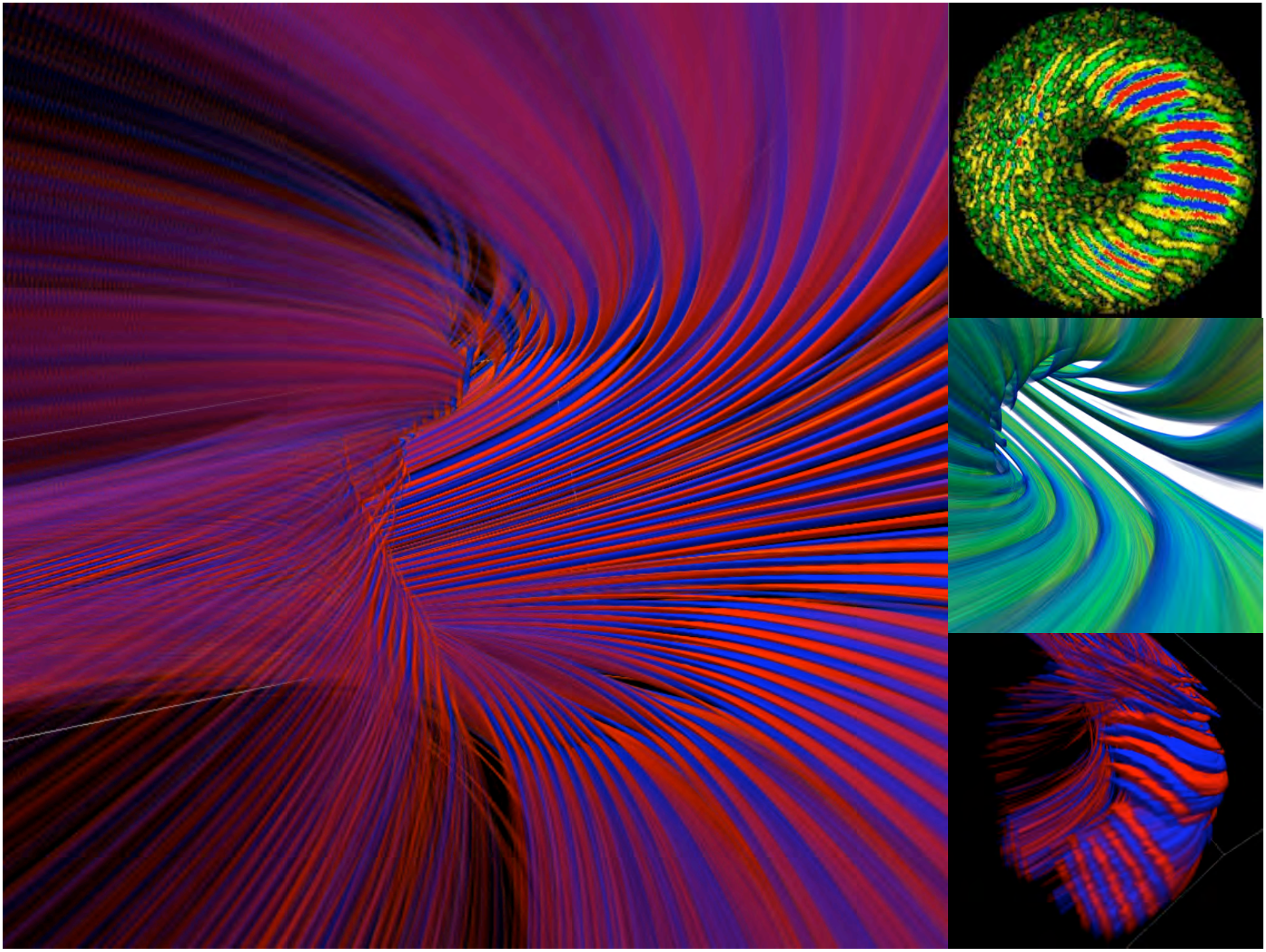
Visualizing Multidimensional Particle Data

Lead: Kwan-Liu Ma



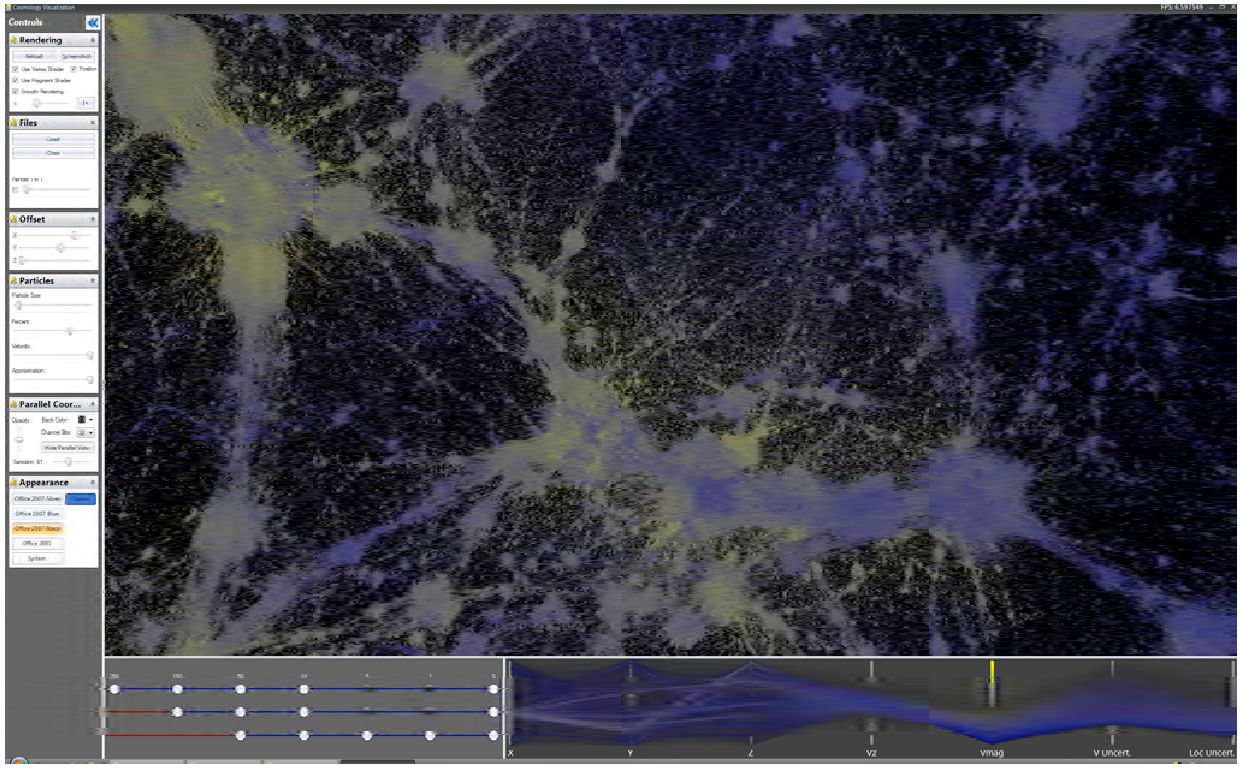
- Collaborators: Stephane Ethier, PPPL
- Publications: IEEE Computing in Science & Engineering, IEEE Computer Graphics & Applications


r^2
Cos_thetab
Rho
Weight
Mu
sqrt(x^2+y^2)



Comparative Visualization of Cosmological Simulations

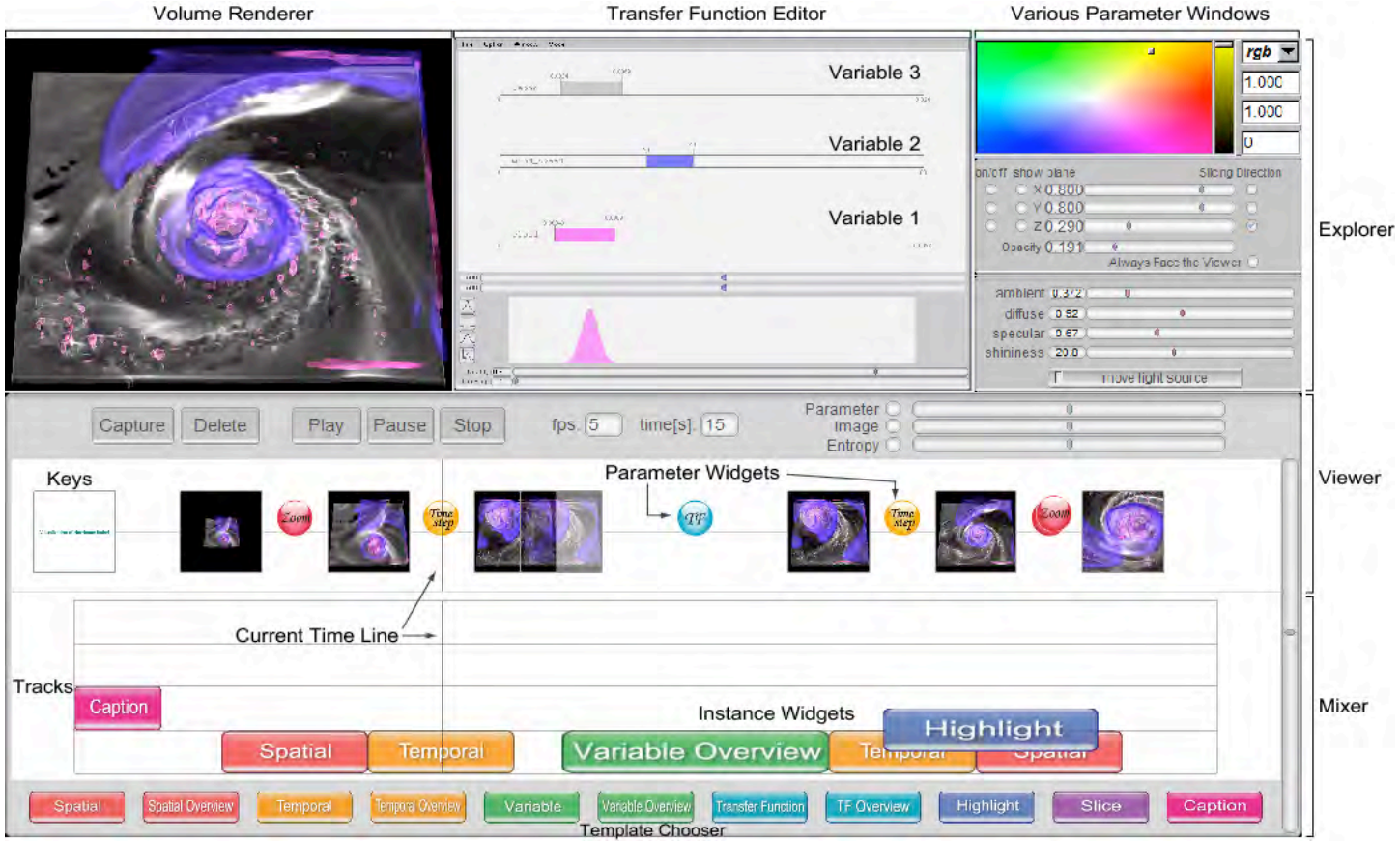
Lead: Kwan-Liu Ma



- Collaborator: Katrin Heitmann, LANL
- Publication: IEEE Computer Graphics and Applications

An Animation Tool for Expressive Visualization

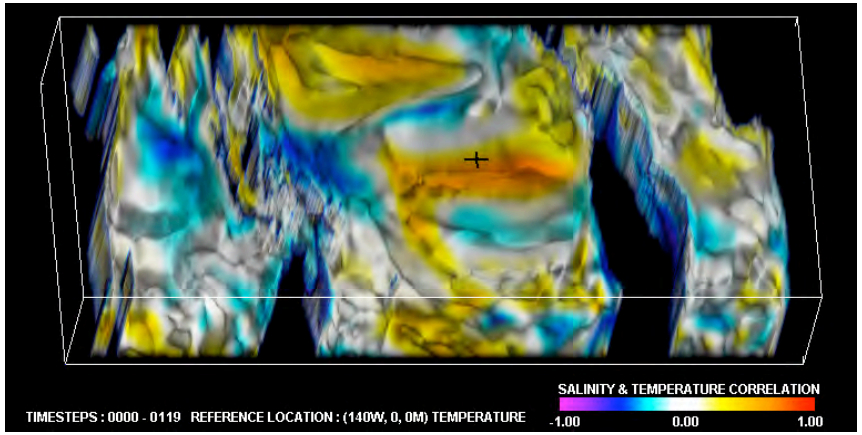
Lead: Kwan-Liu Ma



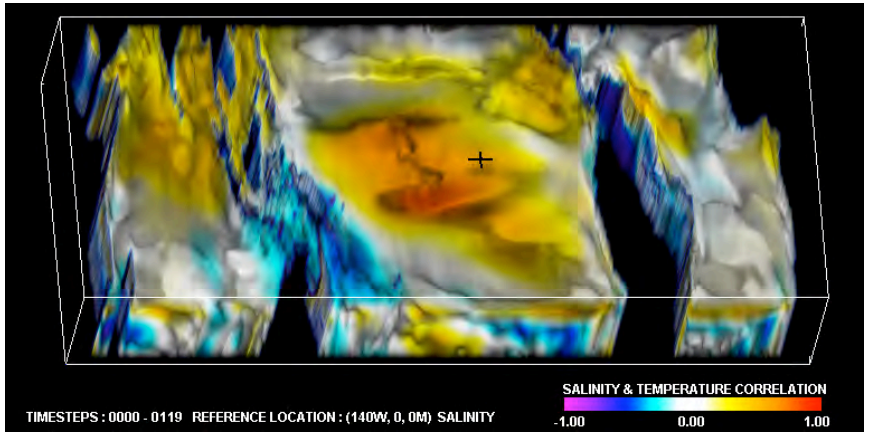
- Publication: Submitted to IEEE Computer Graphics and Applications

Visual Analytics for Climate Data

Lead: Kwan-Liu Ma



Salinity with temperature

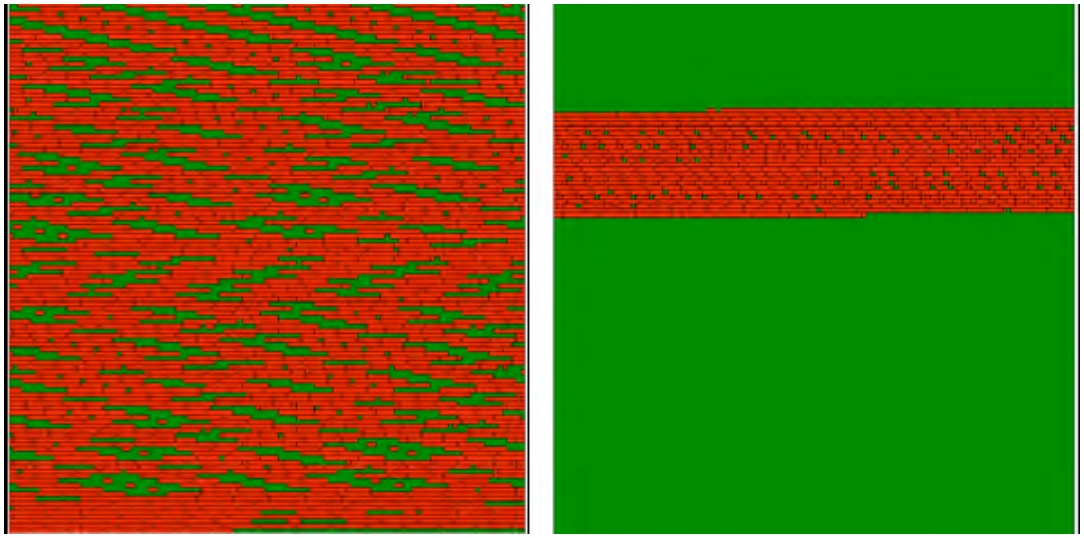


Temperature with salt

- Collaborator: Andrew Wittenberg, NOAA
- Interactive time-dependent 3D correlation analysis
- Publication: submitted to IEEE PacificVis 2009

I/O Optimized Visualization

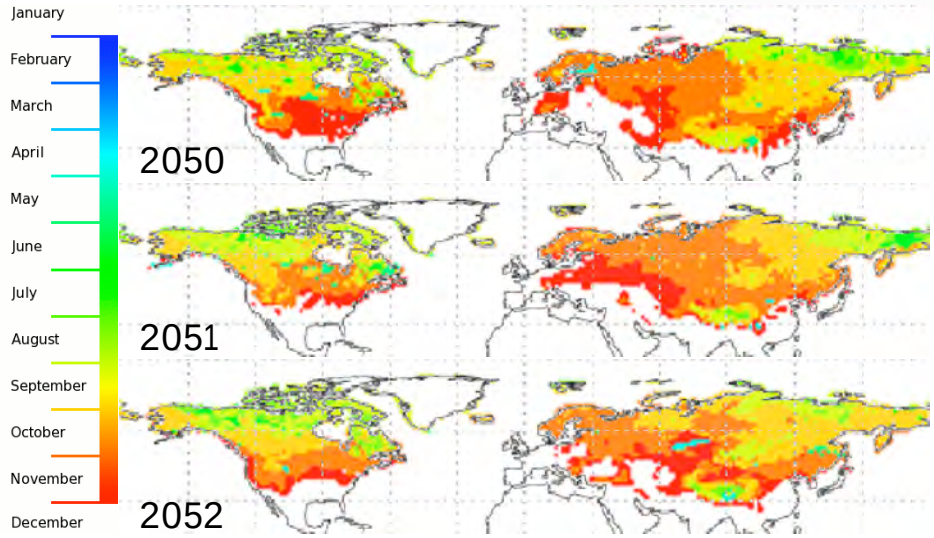
Lead: Rob Ross and Han-Wei Shen



- I/O is one major performance bottleneck for peta-scale visualization
- Better file layout (contiguous read) based on data usage can reduce the I/O cost
- We study the design of optimized file layouts for Parallel Virtual File System (PVFS) on IBM BG/P for large scale volume rendering applications
- Publications: R. Ross et al. Visualization and Parallel I/O at Extreme Scale, in Proceedings of SciDAC 2008, Journal of Physics: Conference Series.

Concept Oriented Exploration

Lead: Jian Huang

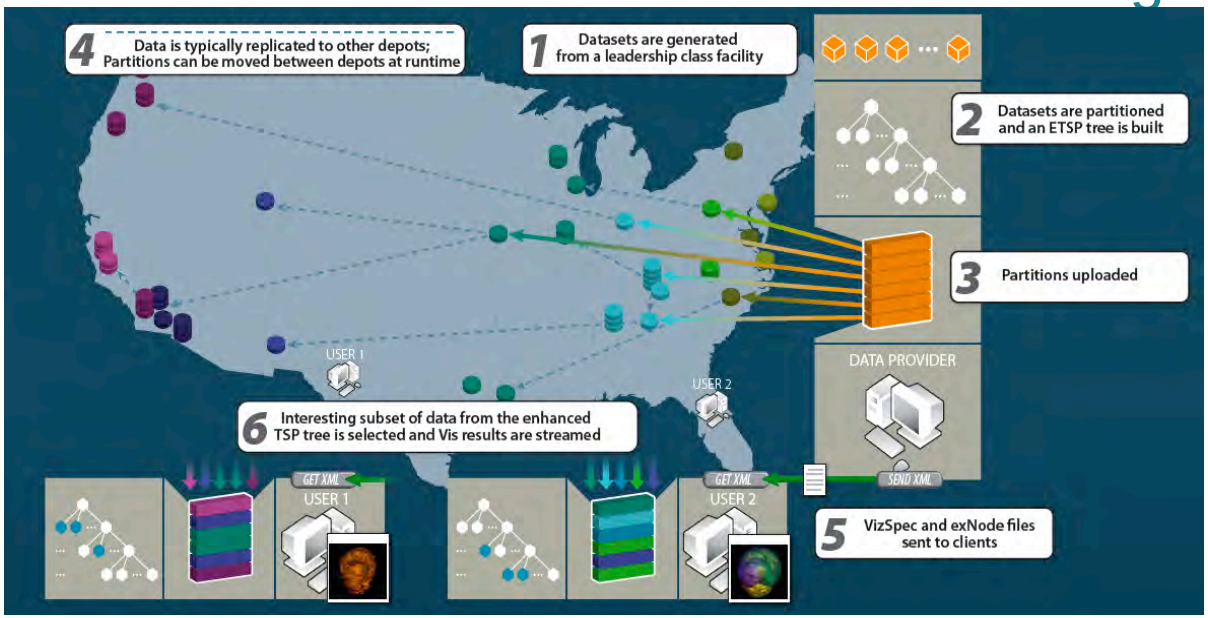


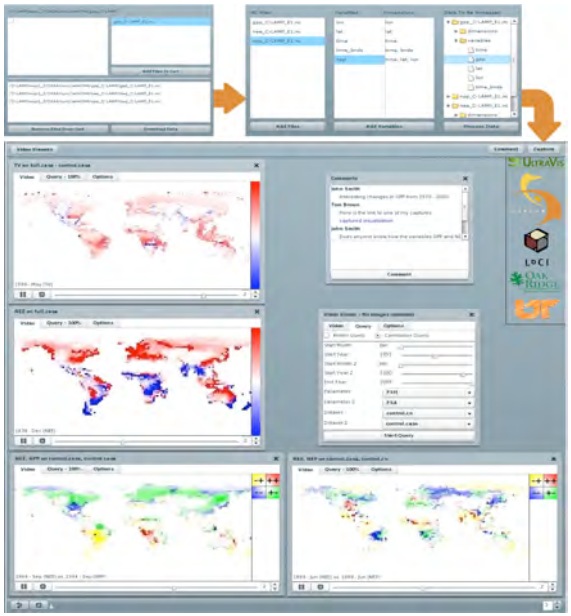
"First Snow": Northern Hemisphere colored by month of event in variable FSNO

- The process of discovery is *concept-oriented* and often based on imprecise information
- *Meta-queries* accept partially defined concepts about patterns and expand them into a series of completed queries
- How well can time varying data match user concepts in competing climate models?
- Collaborators: Forrest Hoffman, David Erickson III,ORNL
- Publication: IEEE TVCG (Vis 2008)

Remote Collaborative Visualization

Lead: Jian Huang



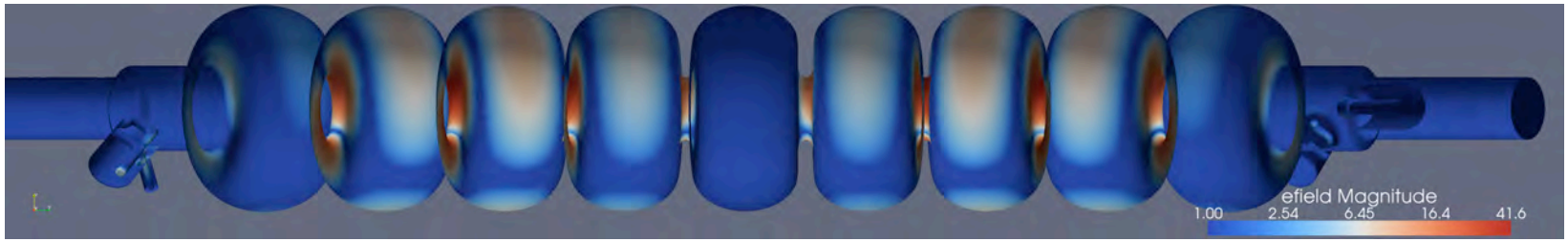


- Optimal configurations, scheduling algorithms, image-based rendering algorithms, sharing using heterogeneous parallelism, remote visualization interfaces and interaction techniques
- Collaborators: Nagiza Samatova, SDM center
  Forrest Hoffman, David Erickson III,
  John Drake, ORNL
  Mike Papka, Argonne
- Publication: IEEE Transactions (TVCG) 2007, CTS 2008

ParaView Deployment at SLAC

Lead: Ken Moreland

- Collaborator: Greg Schussman, SLAC
- Using ParaView to provide parallel visualization capabilities.
- Technical challenges:
  - Supporting file formats.
  - Adapting to unique data structures.
  - Implementing visualization modes specific to SLAC.



Ongoing and Following Projects

- In situ data reduction and packing, and visualization
- Feature extraction, tracking, and classification
- Remote and collaborative visualization/analysis interfaces
- Novel flow visualization techniques
- Time-varying multivariate data visualization
- Multi-GPU computing
- Parallel visualization algorithms and libraries
- Visual analysis of Leadership Computing System Performance
- Next generation visualization systems

SciDAC Collaborators

- VACET (MultiGPU applications, multivariate data vis, workshops)
- SDM (Vis/analysis dashboard, indexing)
- CDEPS (Data transferring)
- CScADS (Workshops)
- ESG-2 (web interfaces for climate modeling)
- CSCAPES (mesh partitioning, mesh visualization)
- Petascale Data Storage Institute (test cases for POSIX I/O)
- COMPASS
- CEMM
- GPS-TTBP
- GSEP
- Groundwater Simulations
- Climate Modeling
- Supernova Simulations
- Combustion Simulations

Outreach and Education

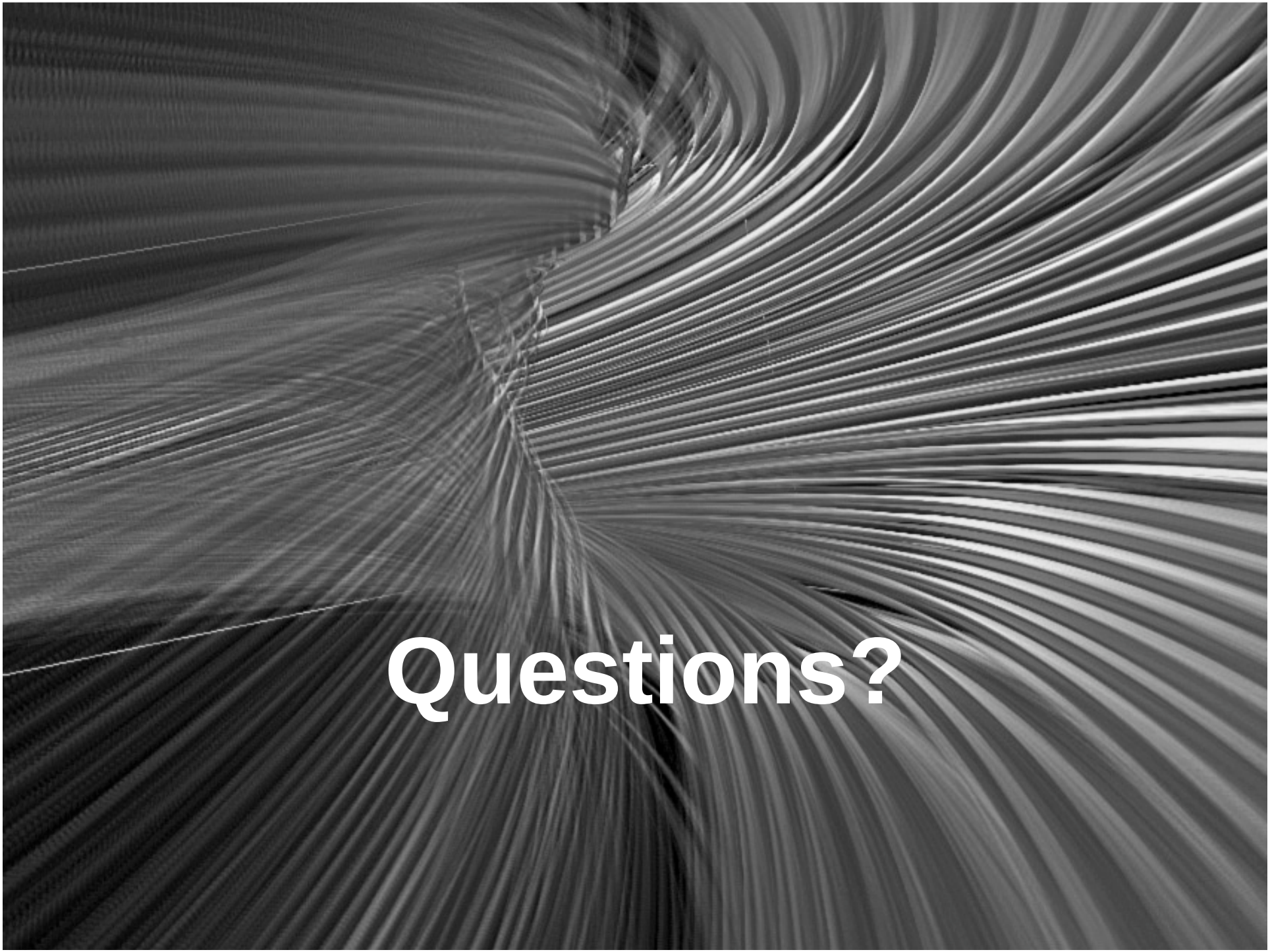
- Workshops: **Annual Ultrascale Visualization Workshop**
- Tutorials: SC, VisWeek, SIGGRAPH, SIAM, …
- Courses: UCD, UVA, UT, Ohio State
- Panels: **Meet the Scientists, …**
- Data repositories: **VisFiles**
- Beyond SciDAC: NOAA, Harvard Smithsonian Center for Astrophysics, NCAR, NSF PetaApps Earthquake Modeling Project, …
- Upcoming: Software deployment and distributions, benchmarks, International collaborations, museum exhibits, …

Software

- Research prototype systems
- Direct deployment in the scientist’s laboratory
- Open Source Software Distribution via ParaView
- Libraries
- Tech Transfer to Commercial Software Toolkits

Advisory Board

- James Ahrens, Los Alamos National Laboratory
- Jackie Chen, Sandia National Laboratories
- Hans-Christian Hege, ZIB, Germany
- Tony Mezzacappa, Oak Ridge National Laboratory
- John van Rosendale, College of William and Mary


Questions?